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Maximum Surface Concentration of SO2 from a Moderate-Size Steam-Electric Power Plant as a Function of Power Plant Load

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TECHNICAL NOTE

MAXIMUM SURFACE CONCENTRATION OF SO_2 FROM A MODERATE-SIZE STEAM-ELECTRIC POWER PLANT AS A FUNCTION OF POWER PLANT LOAD

(*First received* 17 *March* 1978 *and in final form* 27 *July* 1978)

Abstract – Using the reported effluent characteristics from a moderate-size power plant, a simulation of the maximum ground-level concentrations of SO_2 was conducted using a simple Gaussian plume model. The results suggest that high surface concentrations can occur even when the SO_2 emission rate is significantly reduced by lowering the power load of the power plant.

INTRODUCTION AND PROCEDURE

Using the reported effluent characteristics from a moderate-size steam-electric power plant, Fig. 1, and a numerical, steady-state, Gaussian plume model, PTMAX*, the variation of the maximum ground-level SO_2 concentrations were investigated as a function of power-plant operating characteristics. Variations in operating characteristics can affect concentration estimates since the buoyant plume rise predictions (Briggs, 1969, 1971, 1972) are functions not only of the ambient air temperature and the wind speed, but are also functions of the stack gas temperature and the stack gas exit velocity. All other factors being equal, a reduction in power load results in a reduction in SO_2 emissions, see Fig. 1. However, a power load reduction also decreases the stack gas exit temperature and exit velocity which results in a lower plume rise and hence tends to increase ground-level concentration estimates. For this investigation estimates of ground-level concentrations were made by executing PTMAX 22 times: 11 times using the various operating characteristics shown in Fig. 1, where the power load was increased in 30 mW increments from 50 to 350 mW (full load); 11 times using the same procedure except the stack gas temperature was held constant at 447.4 K (effluent temperature for maximum load conditions). In modeling practice the variation of the stack gas temperature as a function of power load is often not known. Large sources are usually characterized by one "typical" stack gas temperature, with little guidance as to the variation of the temperature with operating conditions. Therefore, it seemed of interest to compare concentration estimates obtained using a single value for the stack temperature with those obtained using realistically varied stack temperatures.

RESULTS AND CONCLUSIONS

(1) The highest concentration estimates occurred for the unstable stability categories (Pasquill stability categories A and B).

(2) With the exception of stability category C, the peak estimated concentration for each stability category occurred at some power load below 350 mW, when all the operating chatacteristics, including stack temperature, were varied as a function of power load. For example, Fig. 2 shows that for stability category B, the peak estimated concentration of 327 μg^{-3} occurred at 230 mW.

(3) Conversely, when the stack temperature was held constant at 447.4 K, the peak estimate always occurred at 350 mW, as shown for stability B in Fig. 2.

(4) Within each Pasquill stability category, the maximum concentration estimates (over all wind speeds used) for power loads greater than or equal to 200 mW were within 10% of the peak estimated concentration, when all the operating characteristics were varied as a function of power load. 200 mW is 57% of full load. This result is evident in Fig. 2, for stability category B.

The results of this study demonstrate the sensitivity of concentration estimates for elevated buoyant releases, not only to the pollutant emissions rate, but to the effluent characteristics as well. It should be noted, however, that the inaccuracies inherent in Gaussian plume modeling (Weber, 1976) do not permit the attachment of any great significance to the fact that some partial-load maximum concentration estimates actually exceed that estimated for full load (as in Fig. 2). These results are valid only for dispersion which is adequately modeled using the Gaussian plume model as described by Turner (1970) and for plume rise which is adequately modeled using the procedures incorporated in PTMAX and described by Briggs (1969, 1971, 1972).

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* PTMAX was derived from Figs. 3–9 of Turner (1970), and is part of a numerical package collectively referred to as UNAMAP, User's Network for Applied Modeling of Air Pollution (Hosler, 1975). Output from PTMAX in addition to the maximum ground-level concentration, includes the downwind distance to the point of maximum concentration, and the effective height of emission. With each execution of PTMAX, the above three quantities are computed, using appropriate wind speeds, for six Pasquill stability categories (A through F). Since the Pasquill dispersion parameters (Turner, 1970) are used in PTMAX, the resulting concentration estimates are typical of averaging times on the order of 10 minutes.

† On assignment from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

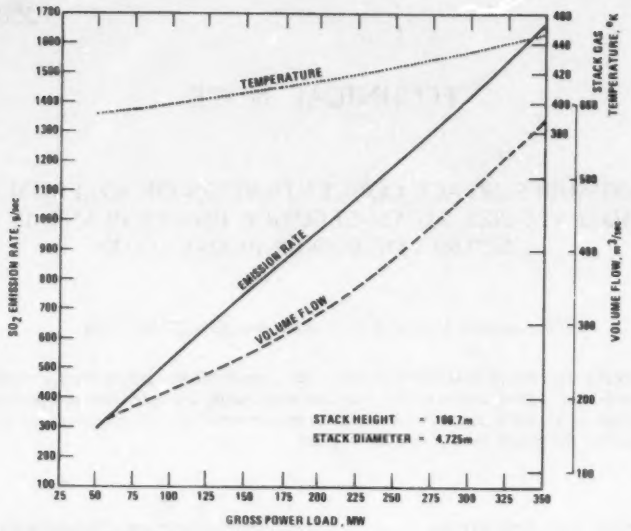

Fig. 1. Source operating characteristics vs gross power load (mW).

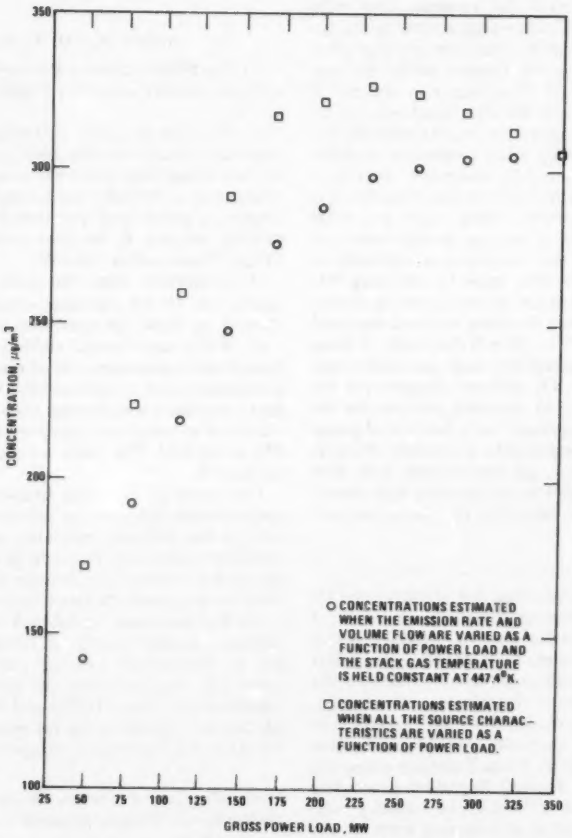
CONCENTRATION, $\mu g/m^3$
O CONCENTRATIONS ESTIMATED WHEN THE EMISSION RATE AND VOLUME FLOW ARE VARIED AS A FUNCTION OF POWER LOAD AND THE STACK GAS TEMPERATURE IS HELD CONSTANT AT 447.4°K.
□ CONCENTRATIONS ESTIMATED WHEN ALL THE SOURCE CHARACTERISTICS ARE VARIED AS A FUNCTION OF POWER LOAD.
GROSS POWER LOAD, MW

Fig. 2. Maximum ground-level concentration ($\mu g\,m^{-3}$) vs gross power load (mW) for Pasquill stability category B, with stack gas temperature varied and held constant. In both cases, the maximum concentration estimate at each power load occurred at the highest wind speed allowed for B stability, 5 m s^{-1}. An assumed constant ambient air temperature of 293 K was used in the dispersion calculations.

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